

Argyroxiphium sandwicense subsp. *sandwicense*
(Ahinahina or Mauna Kea Silversword)

**5-Year Review
Summary and Evaluation**

**U.S. Fish and Wildlife Service
Pacific Islands Fish and Wildlife Office
Honolulu, Hawaii**

5-YEAR REVIEW

Species reviewed: *Argyroxiphium sandwicense* subsp. *sandwicense* (Ahinahina or Mauna Kea Silversword)

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5-YEAR REVIEW
Argyroxiphium sandwicense* subsp. *sandwicense
(Ahinahina or Mauna Kea Silversword)

1.0 GENERAL INFORMATION

1.1 Reviewers

Lead Regional Office:

Region 1, Endangered Species Program, Division of Recovery, Jesse D'Elia, (503) 231-2071

Lead Field Office:

Pacific Islands Fish and Wildlife Office, Loyal Mehrhoff, Field Supervisor, (808) 792-9400

Cooperating Field Office(s):

N/A

Cooperating Regional Office(s):

N/A

1.2 Methodology used to complete the review:

This review was conducted by staff of the Pacific Islands Fish and Wildlife Office of the U.S. Fish and Wildlife Service (USFWS), beginning on April 8, 2010. The review was based on the final rule to list *Argyroxiphium sandwicense* ssp. *sandwicense* (USFWS 1986) and the recovery plan for the Mauna Kea silversword (*Argyroxiphium sandwicense* ssp. *sandwicense*) (USFWS 1993), as well as a review of current, available information. The Bernice Pauahi Bishop Museum provided an initial draft of portions of the review and recommendations for conservation actions needed prior to the next five-year review. The evaluation of Samuel Aruch, biological consultant, was reviewed by a recovery biologist and the Plant Recovery Coordinator. The document was then reviewed by the Recovery Program Leader and the Assistant Field Supervisor for Endangered Species before submission to the Field Supervisor for approval.

1.3 Background:

1.3.1 Federal Register (FR) Notice citation announcing initiation of this review:

[USFWS] U.S. Fish and Wildlife Service. 2010. Endangered and threatened wildlife and plants; initiation of 5-year status reviews of 69 species in Idaho, Washington, Hawaii, Guam, and the Commonwealth of the Northern Mariana Islands. Federal Register 75(67):17947-17950.

1.3.2 Listing history

Original Listing

FR notice: USFWS. 1986. Endangered and threatened wildlife and plants; determination of endangered status for *Argyroxiphium sandwicense* ssp. *sandwicense* (Ahinahina or Mauna Kea Silversword). Federal Register 51(55):9814-9820.

Date listed: March 21, 1986

Entity listed: Subspecies

Classification: Endangered

Revised Listing, if applicable

FR notice: N/A

Date listed: N/A

Entity listed: N/A

Classification: N/A

1.3.3 Associated rulemakings:

Critical habitat was not designated for *Argyroxiphium sandwicense* subsp. *sandwicense* because there would be no net benefit to the species and that designating critical habitat could make the species more vulnerable to acts of vandalism (USFWS 1986).

1.3.4 Review History:

Species status review [FY 2011 Recovery Data Call (August 2011)]:
Stable

Recovery achieved:

2 (0-25%) (FY 2007 Recovery Data Call)

1.3.5 Species' Recovery Priority Number at start of this 5-year review:

6

1.3.6 Current Recovery Plan or Outline

Name of plan or outline: U.S. Fish and Wildlife Service. 1993. Recovery Plan for the Mauna Kea Silversword (*Argyroxiphium sandwicense* ssp. *sandwicense*). U.S. Fish and Wildlife Service, Portland, Oregon. 48 pages.

Date issued: September 30, 1993

Dates of previous revisions, if applicable: N/A

2.0 REVIEW ANALYSIS

2.1 Application of the 1996 Distinct Population Segment (DPS) policy

2.1.1 Is the species under review a vertebrate?

Yes
 No

2.1.2 Is the species under review listed as a DPS?

Yes
 No

2.1.3 Was the DPS listed prior to 1996?

Yes
 No

2.1.3.1 Prior to this 5-year review, was the DPS classification reviewed to ensure it meets the 1996 policy standards?

Yes
 No

2.1.3.2 Does the DPS listing meet the discreteness and significance elements of the 1996 DPS policy?

Yes
 No

2.1.4 Is there relevant new information for this species regarding the application of the DPS policy?

Yes
 No

2.2 Recovery Criteria

2.2.1 Does the species have a final, approved recovery plan containing objective, measurable criteria?

Yes

No

2.2.2 Adequacy of recovery criteria.

2.2.2.1 Do the recovery criteria reflect the best available and most up-to date information on the biology of the species and its habitat?

Yes
 No

2.2.2.2 Are all of the 5 listing factors that are relevant to the species addressed in the recovery criteria?

Yes
 No

2.2.3 List the recovery criteria as they appear in the recovery plan, and discuss how each criterion has or has not been met, citing information:

A synthesis of the threats (Listing Factors A, C, D, and E) affecting this species is presented in section 2.3.2 and Table 2.

Downlisting and delisting objectives are provided in the recovery plan for the Mauna Kea Silversword (*Argyroxiphium sandwicense* ssp. *sandwicense*) (USFWS 1993). To be considered for downlisting, *A. sandwicense* ssp. *sandwicense* will need to occur in at least three large sites on Mauna Kea, have an expanding population structure with ample evidence of consistent and high regeneration, be genetically diverse, have all known extant populations protected, and have no immediate threats.

This recovery objective has not been met.

To achieve delisting of the species, the subspecies will need to be reestablished in areas of historic abundance or other areas of maximal potential. Active genetic management may also be needed to assure long-term survival of the subspecies.

This recovery objective has not been met.

2.3 Updated Information and Current Species Status

2.3.1 Biology and Habitat

2.3.1.1 New information on the species' biology and life history:

Argyroxiphium sandwicense subsp. *sandwicense* is an erect, single-stemmed and monocarpic (flowering once and then dying), or rarely branched and polycarpic (each rosette flowering and dying separately) rosette shrub in the aster family (Asteraceae). *Argyroxiphium sandwicense* subsp. *sandwicense* is a tall, tap-rooted taxon that produces a dense cluster of basal leaves preceding the formation of a flowering stalk some time later in its life cycle. An individual typically flowers only once during its life (monocarpic), or more infrequently it can form branches from near the base, each of which flowers and subsequently dies back (polycarpic) (Wagner *et al.* 1999; USFWS 1993). *Argyroxiphium sandwicense* subsp. *sandwicense* has a polycarpic, branching habit more frequently than subspecies *macrocephalum* (ahinahina), which was listed as a threatened species in 1992 (USFWS 1992). Individuals may live from 3 to 50 years before flowering (USFWS 1993).

Flowering of *Argyroxiphium sandwicense* subsp. *sandwicense*, which may be entirely absent in some years (R. Robichaux, Professor of Biology, University of Arizona, pers. comm. 2001), occurs between June and September (USFWS 1993; Bishop Museum 2011; National Tropical Botanical Garden 2011). Fruiting likewise occurs from June through September (Bishop Museum 2011; National Tropical Botanical Garden 2011). *Argyroxiphium sandwicense* subsp. *sandwicense* is mostly self-incompatible, which means it is dependent on insects or other vectors to pollinate its flowers. Dispersal of the seeds occurs by wind and water. Large numbers of seeds (*e.g.*, 33,750 in the year 1988) were germinated experimentally between 1973 and 1988, and in no case did the germination rate equal even 10 percent of the seeds collected (USFWS 1993).

Observed and recorded hybridization events appear to be generally rare in the wild for *Argyroxiphium sandwicense* subsp. *sandwicense*. However, a putative (generally believed to be) hybridized individual with *Dubautia arborea* ([Carr 1521] Bishop Museum 2011) was identified by Dr. Gerald Carr above Puu Laau, who monographed the silverswords (Carr 1985).

A number of anatomical studies have been carried out on *Argyroxiphium sandwicense* at the species- and at the subspecies-level. Carlquist (1957) noted the presence of pectic (water-soluble colloidal carbohydrates of high molecular weight) channels in the relatively loosely arranged mesophyll (middle layer) in the leaves of *Argyroxiphium sandwicense* (studied at the species-level). Also noteworthy in his view (Carlquist 1957) was that the lowermost of three vascular bundles in the leaf (in cross section) is inverted. The reversed orientation was explained by the appearance of an “abaxial meristem” in the leaf surfaces, which gives rise only to the lowermost (as viewed in cross section) of the three vascular bundles. Carlquist (1997) later studied the anatomy of the basal stem and “wider root” (presumably root crown) of *A. sandwicense*. However, since neither study specified which subspecies were being studied, clarification is provided here for future reference. Joy England (Rancho Santa Ana Botanic Garden, pers. comm. 2011) confirmed that the voucher specimen cited in Carlquist (1997 [Carlquist 544]) was collected on Maui, thus making it *A. sandwicense* subsp. *macrocephalum*. The specimens cited in Carlquist (1957) were likely from Maui, since one of the species in that study, *A. caliginis*, is endemic to Maui. Thus, the results of the earlier study also likely did not refer to *A. sandwicense* subsp. *sandwicense*.

Carr and Kyhos (1981) recorded spontaneous hybrids between *Argyroxiphium sandwicense* subsp. *sandwicense* and *A. virescens* based on $n = 14$ in each taxon. In meiosis, the hybrid showed twelve pairs and one multi-valent ring of four chromosomes. The authors later reported artificial hybridization between *A. sandwicense* subsp. *sandwicense* and *A. grayanum* with a pollen stainability of 62 percent, indicating a fairly high level of fertility between the taxa, and having the same meiotic configuration of 12 bivalents and 1 multivalent (Carr and Kyhos 1986).

Baldwin and Robichaux (1995) studied phylogenetic relationships in the Hawaiian silversword alliance, including members of the genera *Argyroxiphium*, *Dubautia*, and *Wilkesia*. Using DNA sequences from the internal transcribed spacer (ITS) regions of nuclear ribosomal region, their data suggested that both varieties of *A. sandwicense* were members of an unresolved clade that included *A. kauense*, *A. grayanum*, and *A. caliginis* (Baldwin and Robichaux 1995).

Insect pollinators of *Argyroxiphium sandwicense* subsp. *sandwicense* include native bee species of the genera *Hyleus* (formerly *Nesoprosopis*), and moths of the genera *Scotorytha* and *Agrostis* (USFWS 1993).

A study by Walker and Powell (1995) focused on the factors that affect germination of *Argyroxiphium sandwicense* subsp. *sandwicense*. The authors made several important findings: germination occurred best in moist and shady environments; removal of the pericarp (outer seed coat) greatly enhanced germination rates; germination success was highest among field-collected seed less than two years old; cold and heat pretreatments did not affect germination; germination success was reduced in seeds that were collected on the ground or in the soil; low germination in the field likely is a significant factor limiting recruitment in the field; and grasses are significant competitors with the subspecies in mesic environments. Later work (Walker and Powell 1999) by these authors additionally demonstrated that germination in the field was best on gravel-covered surfaces, and that the presence of trees and shrubs in the immediate vicinity enhanced germination rates but decreased growth and reproduction. Further, they determined that the most ideal conditions for growth vary during the life cycle of the subspecies, and that the stages in which cultivation and propagation is most critical are pollination, seed production, seed germination, and survival of seedlings (Walker and Powell 1999).

2.3.1.2 Abundance, population trends (e.g. increasing, decreasing, stable), demographic features (e.g., age structure, sex ratio, family size, birth rate, age at mortality, mortality rate, etc.), or demographic trends:

In the late 1980s, *Argyroxiphium sandwicense* subsp. *sandwicense* was said to consist of a single population of about 30 individuals that occurred in the Wailuku River basin at approximately 2,850 meters (9,350 feet) elevation (Wagner *et al.* 1999). (Note: USFWS [1993] reports that “Wailuku” was sometimes used in error for Waipahoehoe River, although the subspecies was found historically in both Wailuku and Waipahoehoe gulches.) However, the species may have been far more abundant in pre-human times, although there are no records of the extent or density of this species prior to the

introduction of ungulates to the island of Hawaii in 1793 and 1794 (USFWS 1993).

The State of Hawaii reintroduced *Argyroxiphium sandwicense* subsp. *sandwicense* in three exclosures in the Mauna Kea Forest Reserve between 1973 and 1982, including sites near Puu Nanaha at 2,770 meters (9,086 feet) elevation, near the Skyline jeep trail at 2,970 meters (9,742 feet) elevation, and at Waipahoehoe Gulch at 2,800 meters (9,184 feet) elevation. A total of four exclosure sites were in place for *A. sandwicense* subsp. *sandwicense*, in addition to the single wild population (USFWS 1993). The recovery plan (USFWS 1993) also summarized the age classes (seedling, juvenile, adult, and flowering) of the five populations as they occurred in 1991.

At the time of the recovery plan (USFWS 1993; Walker and Powell 1995), *Argyroxiphium sandwicense* subsp. *sandwicense* was estimated to include 495 to 500 individuals, of which about 38 individuals were naturally occurring. By 2000 (R. Robichaux, pers. comm. 2000a), at least 27 maternal individuals had been used in propagation efforts. Survival success rates could be very high over the short term, as evidenced by the 99 percent survival rate between October 1999 and March 2001 for over 900 seedlings that were reintroduced (R. Robichaux, pers. comm. 2000c). More recently, Hatayama (Hawaii Department of Land and Natural Resources, Division of Forestry and Wildlife, pers. comm. 2011b) indicated that survival rate of reintroduced seedlings averaged approximately 70 percent over the past decade or so.

By 2008, a single wild individual of *Argyroxiphium sandwicense* subsp. *sandwicense* was known in Waipahoehoe Gulch (Plant Extinction Prevention Program 2008). Trips to a site at Pohakuloa Gulch between November 2007 and June 2008 yielded a high count of eight individuals (Plant Extinction Prevention Program 2008). In 2009, the number of individuals was reported as 8 in Pohakuloa Gulch and 15 to 16 individuals in Waipahoehoe Gulch (Plant Extinction Prevention Program 2009). An additional nine individuals were discovered from the Mauna Kea Ice Age Natural Area Reserve in April of 2009 in an area where the species was not previously known (Plant Extinction Prevention Program 2009). In October of 2009, a single individual was observed at Hanaipoe gulch (Plant Extinction Prevention Program 2010).

Recent summaries suggest that two wild populations of *Argyroxiphium sandwicense* subsp. *sandwicense* currently exist, comprising only approximately 27 individuals (Plant Extinction Prevention Program 2010; USFWS 2010). Several outplantings presently exist that collectively harbor at least 10,000 individuals (USFWS 2010; J. Hatayama, Protection Forester, Hawaii Department of Land and Natural Resources, Division of Forestry and Wildlife, pers. comms. 2011a,b,c), but details concerning the number of outplanted populations and number of individuals within each outplanted population have not been confirmed with certainty. Data are not available that summarize what proportion of individuals flowered (and presumably die) each year (J. Hatayama, pers. comm. 2011a,b). What is certain, however, is that most individuals are on the east and north slopes of Mauna Kea between Kanakaleonui and the road accessing the summit, and most of these are in the Wailuku enclosure; smaller populations (numbers unknown) persist in the skyline and Puu Nanana enclosures; nearly all surviving individuals were reintroduced; seedling survival in the wild is nearly non-existent; and the subspecies is not sustaining itself naturally due to high seedling mortality (J. Hatayama, pers. comm. 2011a,b,c). Hatayama (pers. comm. 2011c), for example, reported having seen only a single naturally germinated seedling over a period of seven years; however this seedling has not been seen in two years and evidently has since perished.

2.3.1.3 Genetics, genetic variation, or trends in genetic variation (e.g., loss of genetic variation, genetic drift, inbreeding, etc.):

Friar *et al.* (1996) studied genetic variation in both subspecies of *Argyroxiphium sandwicense* following the population crash in the early to mid-1990s of subspecies *sandwicense*. Their results indicated that despite the reduction in size to approximately 46 individuals in the wild at that time, the subspecies *sandwicense* had not undergone a large loss of genetic variability, at least as measured by RAPD (randomly amplified polymorphic DNA) markers. These results were encouraging with respect to long-term restoration efforts of *A. sandwicense* subsp. *sandwicense* (Friar *et al.* 1996).

A team also led by Friar found similar results a few years later using eight microsatellite loci (Friar *et al.* 2000). A major finding of both studies was that the amount of genetic variation in subspecies *sandwicense* was only slightly less than that of subspecies *macrocephalum* on Maui, the latter of which comprised in excess of 60,000 individuals at that time, and which never apparently had less than approximately 4,000 individuals (Friar *et al.* 1996, 2000). Another important conclusion of the later study (Friar *et al.* 2000) was that both genetic and demographic components of a taxon must be given close consideration for successful conservation, which accords with one view that stresses both the demographic (*i.e.*, ecological) and genetic aspects of species for conservation (Templeton 1989).

2.3.1.4 Taxonomic classification or changes in nomenclature:

Argyroxiphium sandwicense subsp. *sandwicense* is a rosette shrub in the aster family (Asteraceae). The first specimens of *Argyroxiphium sandwicense* subsp. *sandwicense* were collected in 1825 by James Macrae, which were sent to A.P. de Candolle in Geneva, who described the species (de Candolle 1836). Hooker (1837) renamed the species shortly thereafter, being unaware of its description by de Candolle. The only synonym currently associated with the subspecies is *A. douglasii* Hook (Wagner *et al.* 1999). According to handwritten notes on a specimen at Bishop Museum (2011) collected in 1910 (*Rock 8434*), based on information provided by the native Hawaiian cultural scholar Mary Kawena Pukui in April 1952, additional traditional names for *Argyroxiphium sandwicense* subsp. *sandwicense* include pohinahina and hinahina.

As recognized by Wagner *et al.* (1999), *Argyroxiphium sandwicense* comprises two subspecies: *A. sandwicense* subsp. *sandwicense*, which occurs on Hawaii Island, and *A. sandwicense* subsp. *macrocephalum*, which is restricted to Maui. This classification was based in part on morphometric work by Meyrat *et al.* (1983), and has been followed by all recent works (e.g., Baldwin and Robichaux 1995; Barrier *et al.* 1999; Friar *et al.* 1996).

2.3.1.5 Spatial distribution, trends in spatial distribution (e.g. increasingly fragmented, increased numbers of corridors, etc.), or historic range (e.g. corrections to the historical

range, change in distribution of the species' within its historic range, etc.):

See section 2.3.1.2 above.

2.3.1.6 Habitat or ecosystem conditions (e.g., amount, distribution, and suitability of the habitat or ecosystem):

Argyroxiphium sandwicense subsp. *sandwicense* has been known to occur historically only from the alpine areas of the Mauna Kea volcano on barren alpine cinder desert, scrub desert at the original tree line on Mauna Kea, and open forest of *Sophora chrysophylla* (mamane) (USFWS 1993). The estimated original range for the subspecies was between 2,600 and 3,800 meters (8,528 and 12,464 feet) elevation on all slopes of Mauna Kea (USFWS 1993), and the subspecies has been confirmed growing as high as 3,734 meters (12,250 feet) elevation (Hawaii Biodiversity and Mapping Program 2010). The only soil group the subspecies has been recorded in association with is typical vitrandepts (having a thick mantle of volcanic ash) (Hawaii Biodiversity and Mapping Program 2010), but this likely reflects the fact that insufficient time has elapsed since recent major lava flows during the past 200 years or so for soil formation to form over the highly stony, cinder substrates on much of Mauna Kea.

Plant cover in portions of the historical range of *Argyroxiphium sandwicense* subsp. *sandwicense* can be sparse, given the nature of the substrates and the high altitude (USFWS 1993). Native plant species found in association with the subspecies include *Agrostis sandwicensis* (no common name), *Coprosma ernodeoides* (hupilo, aiakanene), *Dubautia arborea* (kupaoa), *D. cililolata* (naenae), *Pteridium aquilinum* var. *decompositum* (kilau), *Leptecophylla tameiameia* (pukiawe), *Trisetum glomeratum* (pili uka), and *Vaccinium peleanum* (ohelo) (USFWS 1993; Hawaii Biodiversity and Mapping Program 2010; Bishop Museum 2011; National Tropical Botanical Garden 2011).

2.3.1.7 Other:

No new information.

2.3.2 Five-Factor Analysis (threats, conservation measures, and regulatory mechanisms)

2.3.2.1 Present or threatened destruction, modification or curtailment of its habitat or range:

None listed

2.3.2.2 Overutilization for commercial, recreational, scientific, or educational purposes:

Threats:

- Collection (USFWS 1993).

2.3.2.3 Disease or predation:

Threats:

- Ungulate predation or herbivory:
 - Feral sheep (*Ovis aries*) and other ungulates readily eat the relatively succulent leaves of *Argyroxiphium sandwicense* subsp. *sandwicense*. Human-mediated declines in the overall population size, indirectly due to the intentional introduction of ungulate species such as cattle (*Bos taurus*), goats (*Capra hircus*), and sheep, may have occurred as much as 186 years ago, given that an early collector of specimens, James Macrae, observed a dead sheep near the summit of Mauna Kea in 1825 (USFWS 1993). However, none of the early collectors of the subspecies such as James Macrae, David Douglas from Scotland, or Charles Pickering of the U.S. Exploring Expedition noted the relative abundance of the species. It appears that the first recorded statement about relative abundance of the subspecies was by W. D. Alexander in 1892, who stated that it was nearly extinct “except in the most rugged and inaccessible places.” Sheep may have been driven to the highest portions of Mauna Kea due to hunting pressure from humans and feral dogs, and the succulent leaves of *Argyroxiphium sandwicense* subsp. *sandwicense* likely were preferentially browsed by sheep in the

arid, alpine habitat of Maua Kea. The grazing pressure may have been enormous, given one estimate of approximately 40,000 sheep on Mauna Kea in the late 1930s. Goats also damage the subspecies (USFWS 1993)

- Feral pigs (*Sus scrofa*) up root and damage the species (USFWS 1993)
- Invertebrate predation or herbivory – Kobayashi (1974) reported that *Argyroxiphium sandwicense* is largely unaffected by insect predation in the seedling stage, and that such predation mostly commences after the terminal inflorescence forms. The predators most affecting this subspecies are *Rhynchephestia rhabdotis* and *Tephritis cratericola*, which feed on developing seeds. However, this study focused on subspecies *macrocephalum* (Kobayashi 1974), so it is uncertain whether these findings also apply to subspecies *sandwicense*.
- Rodent herbivory and predation – Rats (Plant Extinction Prevention Program 2008).

Current conservation actions:

- Ungulate exclosures:
 - A feral sheep-proof fenced exclosure was completed in April 2008 and then re-inspected in June, for a population of eight individuals at the Pohakuloa Gulch site (Plant Extinction Prevention Program 2008). At that time plans were forwarded to build an exclosure around another newly discovered individual in an unnamed drainage, which the workers tentatively called “Ahinahina Gulch” (after the Hawaiian name for the plant) (Plant Extinction Prevention Program 2008).
 - In April 2009, a 4.05 hectare (10.0 acre) fenced exclosure was constructed around the nine individuals located within the Mauna Kea Ice Age Natural Area Reserve to exclude feral pigs and hybrid sheep (Plant Extinction Prevention Program 2009).
 - In 2009, six fenced exclosures of approximately 3.0 by 3.0 meters (10 by 10 feet) were constructed by staff from the Plant Extinction

Prevention Program, Robert Robichaux, Hawaii Division of Forestry and Wildlife, and a volunteer at Waipahoehoe Gulch (Plant Extinction Prevention Program 2009). Another enclosure approximately 45.7 by 45.7 meters (150 by 150 feet) was constructed at Pohakuloa gulch by staff from the Natural Area Reserve System and the Plant Extinction Prevention Program (Plant Extinction Prevention Program 2009).

- Excluder fence – An enclosure fence was built to exclude rats (*Rattus* spp.) around the single wild individual that remained in 2007 at Waipahoehoe Gulch (Plant Extinction Prevention Program 2008).

2.3.2.4 Inadequacy of existing regulatory mechanisms:

Threats:

- Lack of adequate hunting regulation in areas with ungulates – The lack of adequate ungulate control and the existence of established hunting programs in areas where *Argyroxiphium sandwicense* subsp. *sandwicense* occurs continue to threaten this species.

2.3.2.5 Other natural or manmade factors affecting its continued existence:

Threats:

- Established invasive plant species competition (USFWS 1993; Hawaii Biodiversity and Mapping Program 2010; Bishop Museum 2011; National Tropical Botanical Garden 2011)
 - *Anthoxanthum odoratum* (sweet vernal grass)
 - *Rytidosperma pilosum* (hairy oat grass)
 - *Verbascum thapsus* (mullein)
- Low numbers – increased likelihood of stochastic extinction due to changes in demography, the environment, genetics, or other factors (J. Hatayama, pers. comm. 2011c; Plant Extinction Prevention Program 2010).

- Climate change – Climate change may pose a threat to this species. However, current climate change analyses in the Pacific Islands lack sufficient spatial resolution to make predictions on impacts to this species. The Pacific Islands Climate Change Cooperative (PICCC) has currently funded climate modeling that will help resolve these spatial limitations. We anticipate high spatial resolution climate outputs by 2013.

Current conservation efforts:

- Captive propagation for genetic storage and reintroduction – The Volcano Rare Plant Facility (2011) reports 260,000 individuals in genetic storage.
- Reintroduction / translocation implementation:
 - Over 2,500 individuals of *Argyroxiphium sandwicense* subsp. *sandwicense* were reintroduced on Mauna Kea in 1999, following the approximately 1,500 specimens that were reintroduced between 1973 and 1998 (Robichaux *et al.* 2000). By 2000, a total of at least 4,000 individuals had been reintroduced on Mauna Kea (R. Robichaux, pers. comm. 2000b).
 - The most complete information presently available concerning population numbers and sizes of *Argyroxiphium sandwicense* subsp. *sandwicense* comes from Jay Hatayama (pers. comms. 2011a,b,c), who has worked for the Hawaii Department of Land and Natural Resources, Division of Forestry and Wildlife since 2004. For the last 15 to 18 years, workers have been outplanting roughly 1,000 seedlings yearly. The current number of individuals surviving is unknown, but Hatayama (pers. comm. 2011b) indicated that the survival rate each year for the seedlings has been between 60 percent and 95 percent (depending mostly on climatic variables such as total rainfall). Hatayama (pers. comm. 2011b) indicated that an approximately 700 seedlings on average have survived each year during this interval, and that some 10,000 individuals likely are alive at the present time. Most of the reintroductions have been at the Wailuku Enclosure, where there are

currently approximately 3,329 individuals, but four other sites each also have from between 429 and 1,280 individuals, for a collective total of approximately 6,067 reintroduced individuals in five populations (J. Hatayama, pers. comm. 2011a).

- Surveys / inventories:
 - In July 2008, the Plant Extinction Prevention Program (2009) surveyed and conducted a census of the wild individuals of *Argyroxiphium sandwicense* subsp. *sandwicense* located at Waipahoehoe and Wailuku streams.
 - In October 2009, the Plant Extinction Prevention Program (2010) conducted a survey for *Argyroxiphium sandwicense* subsp. *sandwicense* at Hanaipoe gulch on Mauna Kea.
- Population viability monitoring:
 - Individuals from the Mauna Kea Game Management Area in Waipahoehoe gulch are monitored by the Plant Extinction Prevention Program (2009).
 - Unfortunately, despite the significant augmentation of the population of *A. sandwicense* subsp. *sandwicense* from outplanting efforts on Mauna Kea by the Division of Forestry and Wildlife, little evidence exists for native recruitment and survival of seedlings for the subspecies, suggesting strongly that it is not a self-sustaining subspecies in the wild (J. Hatayama, pers. comm. 2011c).
- Existing population management and restoration – In 2007, individuals from the Mauna Kea Game Management Area in Waipahoehoe gulch were hand pollinated by staff of the Hawaii Island Plant Extinction Prevention Program (2008).

2.4 Synthesis

The downlisting goals for this species have not been met as there is only a single large reproductive population (Table 1), not all known populations are protected, and not all threats are being managed (Table 2). Therefore,

Argyroxiphium sandwicense subsp. *sandwicense* meets the definition of endangered as it remains in danger of extinction throughout its range

Table 1. Status of *Argyroxiphium sandwicense* subsp. *sandwicense* from listing through 5-year review.

Date	No. wild individuals	No. outplanted	Downlisting Criteria identified in Recovery Plan	Downlisting Criteria Completed?
1986 (listing)	110	Small number	3 large sites on Mauna Kea	No
			Expanding population structure	No
			Genetically diverse	No
			All known extant populations protected	No
			No immediate threats	No
1993 (recovery plan)	38	457	3 large sites on Mauna Kea	No
			Expanding population structure	No
			Genetically diverse	No
			All known extant populations protected	No
			No immediate threats	No
2012(5-year review)	27	10,000	3 large sites on Mauna Kea	Partially: The Waipahoehoe population is large
			Expanding population structure	No
			Genetically diverse	Yes
			All known extant populations protected	Partially: Fenced exclosures constructed (see Table 2)
			No immediate threats	Partially (see Table 2)

Table 2. Threats to *Argyroxiphium sandwicense* subsp. *sandwicense* and ongoing conservation efforts.

Threat	Listing factor	Current Status	Conservation/ Management Efforts
Ungulates – Predation or herbivory, lack of adequate hunting regulations	C, D	Ongoing	Partially: Ungulate exclosures constructed at Waipahoehoe and Pohakuloa gulches
Collection	B	Ongoing	No
Invertebrate predation or herbivory	C	Ongoing	No
Rodent predation or herbivory – Rats	C	Ongoing	Partially: Constructed rat-proof exclosure at Waipahoehoe gulch
Established invasive plant species competition	E	Ongoing	No
Low numbers	E	Ongoing	Partially: Captive propagation for genetic storage and reintroduction, reintroduction, hand pollination, and monitoring
Climate change	A, E	Increasing	No

3.0 RESULTS

3.1 Recommended Classification:

Downlist to Threatened

Uplist to Endangered

Delist

Extinction

Recovery

Original data for classification in error

No change is needed

3.2 New Recovery Priority Number:

Brief Rationale:

3.3 Listing and Reclassification Priority Number:

Reclassification (from Threatened to Endangered) Priority Number: _____

Reclassification (from Endangered to Threatened) Priority

Number: _____

Delisting (regardless of current classification) Priority Number:

Brief Rationale:

4.0 RECOMMENDATIONS FOR FUTURE ACTIONS

- Captive propagation for genetic storage and reintroduction:
 - Collect seed from all wild individuals that may be found for use in propagation, to increase the genetic variability of breeding stock.
 - Continue to collect seed material from all populations. Attach tags to individuals to record which individuals have served as maternal parents in propagation efforts *ex situ*.
- Reintroduction / translocation implementation – Continue to reintroduce the species back into its known historical range.
- Ungulate exclosure:
 - Construct large-scale fences around all existing and any new populations.
 - Monitor fenced exclosures for evidence of breaching by feral ungulates.
- Ungulate control – Protect all populations against disturbances from feral ungulates.
- Surveys / inventories:
 - Resurvey the historical range of *Argyroxiphium sandwicense* subsp. *sandwicense* for additional individuals or populations and to determine the current status of the species.
- Reintroduction / translocation site identification – Conduct surveys to determine which areas would be most appropriate for additional reintroductions. In particular, focus on the northern and western slopes of Mauna Kea, where reintroduction sites are less common.
- Competitive invasive plant species control – Remove invasive introduced plant species around all known populations, especially within fenced exclosures.
- Predator / herbivore control – Control rodents around existing populations.
- Threats research:
 - Develop and implement effective measures to reduce the impact of collection.

- Assess the modeled effects of climate change on this species, and use to determine future landscape needed for the recovery of the species.
- Invertebrate control research – Research the effects of invertebrates around existing and reintroduced populations. If research deemed an immediate threat, determine and implement effective control measures.
- Reintroduced / translocation population management and monitoring – Continue to monitor reintroduced populations twice annually for signs of significant population decreases and for other signs of distress, such as insect damage or evidence of plant disease.
- Alliance and partnership development – Work with Hawaii Division of Forestry and Wildlife and other landowners to initiate planning and contribute to implementation of ecosystem-level restoration and management to benefit this species.

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Signature Page
U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW of *Argyroxiphium sandwicense ssp. sandwicense* (Ahinahina or Mauna Kea Silversword)

Pre-1996 DPS listing still considered a listable entity? N/A

Recommendation resulting from the 5-Year Review:

Delisting
 Reclassify from Endangered to Threatened status
 Reclassify from Threatened to Endangered status
 No Change in listing status

Appropriate Listing/Reclassification Priority Number, if applicable: _____

Review Conducted By:

Chelsie Javar, Fish and Wildlife Biologist
Marie Bruegmann, Plant Recovery Coordinator
Jess Newton, Endangered Species Recovery Program Leader
Kristi Young, Assistant Field Supervisor for Endangered Species

Field Supervisor, Pacific Islands Fish and Wildlife Office

for

Jess Newton

Date 8/28/2012